Young adults' trajectories of Ecstasy use: A population based study

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HIGHLIGHTS

- We examine Ecstasy use trajectories over 30 months in a young adult population
- Low (36%), intermediate (56%), high-use (8%) groups identified by cluster analysis
- All trajectories comprised low/declining levels of use from 12 months onwards
- High-use trajectory peaked at 1–2 days Ecstasy use per week
- High-use linked to subjective effects, social setting and length of use ($\leq$ 3 years)

ARTICLE INFO

ABSTRACT

Young adults' Ecstasy use trajectories have important implications for individual and population-level consequences of Ecstasy use, but little relevant research has been conducted. This study prospectively examines Ecstasy trajectories in a population-based sample. Data are from the Natural History Study of Drug Use, a retrospective/prospective cohort study conducted in Australia. Population screening identified a probability sample of Ecstasy users aged 19–23 years. Complete data for 30 months of follow-up, comprising 4 time intervals, were available for 297 participants (88.4% of sample). Trajectories were derived using cluster analysis based on recent Ecstasy use at each interval. Trajectory predictors were examined using a generalized ordered logit model and included Ecstasy dependence (World Mental Health Composite International Diagnostic Instrument), psychological distress (Hospital Anxiety Depression Scale), aggression (Young Adult Self Report) and contextual factors (e.g. attendance at electronic/dance music events). Three Ecstasy trajectories were identified (low, intermediate and high use). At its peak, the high-use trajectory involved 1–2 days Ecstasy use per week. Decreasing frequency of use was observed for intermediate and high-use trajectories from 12 months, independently of market factors. Intermediate and high-use trajectory membership was predicted by past Ecstasy consumption (>70 pills) and attendance at electronic/dance music events. High-use trajectory members were unlikely to have used Ecstasy for more than 3 years and tended to report consistently positive subjective effects at baseline. Given the social context and temporal course of Ecstasy use, Ecstasy trajectories might be better understood in terms of instrumental rather than addictive drug use patterns.

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1. Introduction

Drug use trajectories have a fundamental bearing on the individual and social consequences of drug use and the policy measures required (Hser, Hamilton, & Niv, 2009). The appropriate design of interventions largely depends upon whether young adults who recurrently use particular drugs are likely to 'spontaneously' reduce or cease use, or persist over a longer life-period in spite of sometimes adverse consequences. The persistence and intensity of drug use patterns may have important implications for the nature of acute and long-term harms. With regard to Ecstasy (3,4-methlyenedioxymethamphetamine; MDMA), a growing body of research indicates that cumulative Ecstasy use exposures could be positively correlated with neuropsychological harm (Biezonski & Meyer, 2011; Fernandez-Serrano, Perez-Garcia, & Verdejo-Garcia, 2011; Nulsen, Fox, & Hammond, 2010). There is information available concerning trajectories of use for stimulants such as

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cocaine and methamphetamine (e.g. Brecht, Huang, Evans, & Hser, 2008; Hser, Huang, Brecht, Li, & Evans, 2008; Kertesz et al., 2012). Yet, despite extensive literature on the potential harms of Ecstasy use, there is little evidence concerning Ecstasy use trajectories.

1.1. Ecstasy use trajectories

Ecstasy is both a stimulant and a hallucinogen. It shares some pharmacological and subjective properties of each drug class, and in a variety of studies a majority of Ecstasy users have been found to use other stimulants or hallucinogens at some stage, often in settings such as 'raves' or other festivals and music events (Degenhardt, Barker, & Topp, 2004; Martins, Mazzotti, & Chilcoat, 2005). For stimulants like methamphetamine and cocaine, trajectories beginning in early adulthood can span more than a decade (Hser et al., 2008; Kertesz et al., 2012). In contrast, hallucinogen trajectories are typically sporadic and short-lived (Nichols, 2004).

It is not known where Ecstasy fits on this spectrum. A prospective population-based German study of young people (initially aged 14–24 years) conducted over 3 to 4 years suggested that Ecstasy use may be transient, with a majority ceasing or reducing use within the study period (von Sydow, Lieb, Pfister, Hofler, & Wittchen, 2002). Unfortunately, Ecstasy in this population study was grouped with stimulants and hallucinogens, making to impossible to distinguish the longitudinal patterns specific to Ecstasy. It is important for the duration and intensity of Ecstasy use to be specifically examined in other population settings.

1.2. Predictors of trajectories

Predictors of Ecstasy use trajectories have not previously been investigated. Trajectories for different drugs are related to their potential for eliciting physiological and/or psychological dependence (Anthony, Warner, & Kessler, 1994; Hser, Longshore, & Anglin, 2007; Hser et al., 2008). Drug dependence is generally associated with longer and more intensive trajectories – characterized by frequent drug use – than would be expected among non-dependent users. However, it is not clear how the construct of dependence applies to Ecstasy. Whereas drug dependence is a single-factor construct, Ecstasy dependence may have two underlying factors, namely 'compulsion' (e.g. unplanned use) and 'escalation' (Bruno, Matthews, Degenhardt, & Gomez, 2009; Degenhardt, Bruno, & Topp, 2010). The validity and utility of these constructs has not been assessed with regard to longitudinal patterns of use.

Life course studies indicate that many people 'grow out' of drug use (Chen & Kandel, 1995). A variety of individual and environmental characteristics (e.g. early exposure to drug use) may increase the likelihood of regular drug use during this period. Later, the emergence of structured commitments such as career and family may prompt a spontaneous or deliberate reduction of drug use (Labouvie, 1996). Alternatively, the fulfillment of age-relevant goals such as finding a sexual partner could reduce the motivation to use.

Other factors that may influence Ecstasy use trajectories have been identified in theories of drug use expectancies and instrumental drug use (Boys & Marsden, 2003; Müller & Schumann, 2011). Expectancies may be formed through social contact with Ecstasy users and early subjective experiences of use. Furthermore, Ecstasy use could potentially be instrumental in the pursuit of adaptive personal goals during early adulthood, such as maintaining social networks, finding sexual partners, and exploring novel environmental stimuli. It has been observed that Ecstasy use can be predicated on attendance at events involving electronic/dance music (e.g. 'raves') where common personal goals are pursued (Peters & Kok, 2009; Peters, Kok, & Schaalma, 2008).

1.3. Market factors

There is a lack of evidence concerning the relationship between market factors and temporal changes in individual levels of Ecstasy use. Cross-sectional research indicates that market factors, including Ecstasy price, availability and quality, may influence consumption decisions (Abdallah, Scheier, Inciardi, Copeland, & Cottler, 2007; Goudie, Sumnall, Field, Clayton, & Cole, 2007). Additionally, the impact of market factors might be contingent on the extent of change and capacity of consumers to adapt (Brunt, Niesink, & van den Brink, 2012). Thus, it is plausible that increases or decreases in personal levels of Ecstasy use could, under some circumstances, be due to market changes rather than the natural course of Ecstasy trajectories.

This study identifies trajectories of Ecstasy use among a population sample of young adults, using cluster analysis of recent levels of Ecstasy use across 4 data collection waves spanning 30 months. Possible predictors of trajectories are examined, including participants' demography, adolescent experiences, psychological health, facets of Ecstasy involvement including lifetime consumption and drug dependence, concurrent use of other drugs, social environment, subjective effects of Ecstasy use, and risk perceptions. The influence of market factors, such as price, availability and quality, on longitudinal changes in Ecstasy use is also assessed.

2. Methods

2.1. Participants

The Natural History Study of Drug Use (NHSDU) is a population-based retrospective/prospective longitudinal study of amphetamine-type stimulant (ATS) use. We used a novel application of population screening to develop a sampling frame and thereby recruit probability samples of young drug users and non-users. A one-page questionnaire examining lifetime drug use was mailed to 19 to 23 year olds; ATS use commences around this age (Australian Institute of Health and Welfare, 2008). The study was described as examining the health of young adults and did not highlight ATS use as a focus. Screening recipients were randomly selected from electoral roll data for Brisbane and the Gold Coast (Queensland, Australia). Voting is compulsory in Australia for all citizens aged 18 years and over. In June 2008 an estimated 82% of eligible 18 to 25 year olds were registered to vote (Australian Electoral Commission, 2008). The screening response rate was 49.9% (N = 12,079).

This study focuses on our sample of Ecstasy users. Screening respondents who used Ecstasy 3 or more times in the past 12 months (N = 477) were eligible. This criterion was used to exclude young adults at an 'experimental' stage of Ecstasy use. At the time of recruitment, 23 eligible respondents had moved interstate or overseas or could not be contacted. Of the remainder, 336 (74.0%) consented to participate. Data was collected at 4 time intervals. Participants were interviewed face-to-face at baseline and 12 months, and surveyed via the Internet at 6 and 30 months. There was little variation between data collection modes regarding drug use disclosure, with no participants recanting Ecstasy use at 6 months and 0.3% (n = 1) recanting at 30 months. From the original sample (N = 336), 95.2% participated at 6 months, 89.5% at 12 months and 90.6% at 30 months. For the present analysis, 11.6% of baseline participants were excluded due to missing data, comprising 37 not participating in all study waves and 2 missing for relevant variables. Non-responders were more likely to be male and working full-time. To some extent this may reflect difficulties we experienced scheduling interviews for full-time workers. Additionally, there was no significant difference between responders and non-responders with regard to key Ecstasy use variables, including age of initiation, lifetime quantity of Ecstasy consumed, years of use, and recent frequency of use. This suggests that levels of Ecstasy are not associated with patterns of study participation. Given the relatively low rate of attrition and the similarity between responders and non-responders, this study only includes the 297 participants (i.e. 88.40%) for whom we have complete data.

2.2. Measures

2.2.1. Ecstasy consumption

At 4 time intervals we asked participants 'in the last month (last 31 days), how many days have you had any Ecstasy?'. This variable was recoded as 'no recent use', 'occasional use (1–2 times per month)', 'frequent use (3–4 times per month)', and 'very frequent use (5 or more times per month)'. The cluster analysis was based upon this ordinal variable. Although participants' levels of Ecstasy use may vary from month to month, the measure was highly correlated with an ordinal measure of past 12 month Ecstasy use administered at baseline (Kendall's tau 0.61, 95% CI 0.57–0.64, $p < 0.001$) which was taken from the Illegal Drug Use Section of the World Mental Health Survey Initiative version of the World Health Organization's Composite International Diagnostic Interview (WMH-CIDI). We also collected a self-reported estimate of the number of pills ever taken. A median of 70 pills was used as a cut-off to indicate high lifetime consumption. We differentiate between the intensity and duration of Ecstasy involvement by including a length of Ecstasy use variable calculated from the number of years since first Ecstasy use (0–3 years, 4–5 years, and 6–11 years). In addition, we created a variable distinguishing those who sometimes acquired Ecstasy to sell for profit.

To gauge the use of drugs that is likely occur concurrently with Ecstasy use, we asked about recent alcohol, methamphetamine and cannabis use at the study baseline. For methamphetamine and cannabis, this was defined as any use in the last month. For alcohol, we used a measure of last month binge use, defined as 6 or more standard drinks on each typical day of use, which is comparable with recognized thresholds for binge drinking and hazardous alcohol use.

2.2.2. Ecstasy dependence

Recent (30-day) and lifetime Ecstasy dependence was evaluated at baseline using the Illegal Drug Use Section of the WMH-CIDI. The instrument applies diagnostic criteria for drug dependence from the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). There is reasonable individual-level concordance between WMH-CIDI drug dependence diagnoses and those from semi-structured clinical interviews (positive predictive value of 82.0 for DSM-IV lifetime diagnoses of drug dependence with abuse; Haro et al., 2006).

2.2.3. Drug use perceptions

At baseline and 12 months we asked about 'positive' psychological effects of Ecstasy (euphoria, increased confidence, increased libido, being talkative, being very friendly and increased empathy/understanding) and 'negative' effects (nervousness, panic attacks or anxiety, paranoia, irritability, aggression or hostility, hallucinations or delusions, tension, depression and mood swings). Positive and negative effects were coded differently, because positive effects were more common. Participants reporting at least 5 (out of 6) positive effects 'every time or nearly every time' they used Ecstasy were classed as having 'strong positive effects' and comprised the upper quartile of participants. Those who experienced one or more negative psychological effects on most occasions were classed as having 'strong negative effects' and comprised roughly the 90th percentile.

At 30 months, we asked participants how risky it is to a person's mental and physical health to use Ecstasy. A dichotomous variable was created to distinguish those who perceived Ecstasy to be 'very risky'.

2.2.4. Drug use environment

At baseline, knowing more than 10 Ecstasy users by name or face was designated as having a large set of Ecstasy-using social contacts. At 6 months we asked about visits to social or recreational venues during the previous 12 months. We created a dichotomous variable of 'recurrent attendance' at electronic/dance music events using a cut-off of attendance at ≥ 2 events in the last 12 months.

2.2.5. Psychological factors

Psychological distress was evaluated using the Hospital Anxiety Depression Scale (HADS; Zigmond & Snaith, 1983), which provides a valid and reliable screen for psychological distress with a Cronbach's alpha of 0.88 to 0.89 (Costantini et al., 1999; Herrmann, 1997). A cut-off of 16 indicates high levels of distress (Bjelland, Dahl, Haug, & Neckelmann, 2002; Crawford, Henry, Crombie, & Taylor, 2001). Aggression was measured using the aggressive behavior subscale of the Achenbach Young Adult Self-Report Scale (YASR; Achenbach, 1997). The YASR is an age-appropriate measure with a Cronbach's alpha of 0.84 averaged across each syndrome (Ferdinand & Verhulst, 1994) and 0.81 for the aggressive behavior syndrome (Najman et al., 2009).

2.2.6. Market factors

At the 12 month follow-up we asked participants who had used Ecstasy in the past 12 months how confident they were that their last pill of Ecstasy contained MDMA (very confident/confident; unsure/skeptical; no recent use). We also calculated the proportion of recent occasions for which the effects of Ecstasy were very much weaker than participants were accustomed to (<50% of occasions; ≥50% of occasions; no recent use). For participants who purchased Ecstasy in the past 6 months, we asked the usual price per pill (5–19 AUD; 20–25 AUD; 26–40 AUD; no recent purchases) and whether they were ever unable to obtain Ecstasy (rarely/never; sometimes/often; no recent attempts to obtain Ecstasy).

2.3. Data analysis

We used K-means cluster analysis, with Euclidean distance as the measure of similarity, to identify Ecstasy use trajectory groups. Groups were based on recent Ecstasy use at each of 4 data collection waves. We chose K-means cluster analysis because it does not require selection of covariates or criteria for allocation of observations to different groups (Jain, 2010). Discerning an appropriate set of factors is problematic due to inadequate etiological evidence concerning Ecstasy use (Degenhardt et al., 2010). Four cluster groups were specified. This number was decided on the basis of previous research (e.g. Hamil-Luker, Land, & Blau, 2004; Kertesz et al., 2012). Two clusters, representing intermediate levels of use, overlapped and were combined to form a 'intermediate use' trajectory cluster. The other clusters were labeled 'low use' and 'high use'. Not all requirements for ordered logistic regression (with cluster groups as outcome) were fulfilled: the proportional odds assumption was met but two variables violated the parallel regression assumption. Consequently, we used the partial proportional odds form of the generalized ordered logit model to assess factors associated with higher trajectories of use (Williams, 2006). In addition, we measured changes in levels of use between 6 and 12 months, by subtracting recent days of use at 12 months from recent days of use at 6 months. A linear regression model assessed the relative contribution of market factors and Ecstasy trajectories to decreased levels of use. Data were analyzed using Stata SE 11.0.

3. Results

3.1. Trajectories

Three cluster groups were identified based on participants' days of Ecstasy use in the last month (31 days) at each data collection interval (Fig. 1). These comprised a 'low-use' group (cluster 1; 35.7% of participants), an 'intermediate-use' group (cluster 2; 56.2%) and a 'high-use' group (cluster 3; 8.1%).

All Ecstasy trajectories were characterized by declining or low stable levels of use by the end of the study period. The intermediate-use group used Ecstasy more than once a month (but less than fortnightly) at baseline and showed sustained reduction in Ecstasy use from 6 months
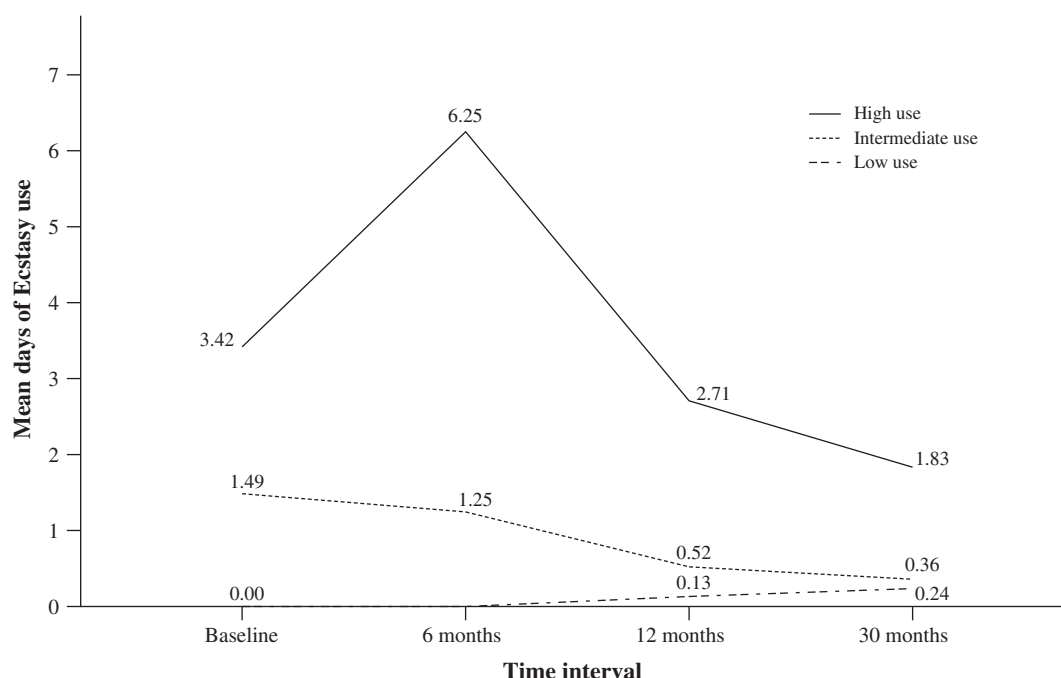
Fig. 1. Ecstasy use trajectories over a 30 month period representing three clusters of longitudinal Ecstasy use patterns: high-use, n = 24 (8.1%), intermediate-use, n = 167 (56.2%), and low-use, n = 106 (35.7%). *Note*: Mean days of Ecstasy use refers to the number of days that Ecstasy was used during the last month at each time interval. Trajectory groups were developed using kmeans cluster analysis.

onwards. By comparison, the high-use group used Ecstasy nearly weekly at baseline and did not show sustained reduction until 12 months. A defining feature of the high-use group was initial escalation up to the level of using more than once a week at 6 months. The low-use group consumed Ecstasy very infrequently (i.e. not every month) but did not cease use altogether.

3.2. Predictors of trajectories

Unadjusted generalized ordered logit analyses were conducted to identify variables associated with Ecstasy use trajectories (Table 1). Membership of the intermediate and high-use trajectories (in contrast to low-use) was positively associated with Ecstasy users' social environment, reporting strong positive effects of Ecstasy at baseline, drug use patterns (high lifetime Ecstasy consumption, Ecstasy dependence, methamphetamine and cannabis use, binge alcohol use) and, perhaps counter-intuitively, successful completion of secondary school education. Being married or in a de facto relationship and perceiving Ecstasy use as very risky were negatively associated with the intermediate and high use trajectories. Psychological distress and aggressive behavior were not associated with Ecstasy trajectories.

We developed a generalized ordered logit model, with adjustment for all variables, to identify independent predictors of Ecstasy trajectories (Table 2). Attendance at electronic/dance music events, high levels of lifetime Ecstasy use prior to baseline (>70 pills ever), and experiencing strong positive subjective effects of Ecstasy at baseline were predictive of intermediate and high-use trajectories, However, reporting the same subjective effects at the 12 month follow-up was not predictive of these trajectories. The association between recent (30 day) Ecstasy dependence and membership of the trajectory groups was non-significant, probably because of the low numbers who were assessed as dependent. (Table 2).

Membership of the trajectories was also predicted by risk perception. Those who perceived Ecstasy use to be very risky were more likely to have a low trajectory of Ecstasy use, rather than intermediate or high-use. The association pertaining to marriage and de facto relationships was non-significant in the adjusted model.

Two factors were unique to the high-use trajectory group. Membership of this group was positively associated with having a history of school suspension, but negatively associated with length of Ecstasy use (>3 years). In other words, being part of the high-use trajectory was associated with a shorter history of use.

3.3. Market factors and changing levels of use

We developed a linear regression model to assess the impact of market factors versus trajectory groupings on changes in Ecstasy use from 6 to 12 months (Table 3). This period represented the most substantial decrease for the intermediate and high-use trajectory groups. There was no apparent association between levels of Ecstasy use and Ecstasy price or availability, but there were modest effects of Ecstasy quality. In the unadjusted analyses, being 'unsure/skeptical' that the pills used contained MDMA (vs. being confident that they did), was associated with an estimated decrease of 0.73 days of recent Ecstasy use. In the full model, adjusted for Ecstasy trajectories and all market variables, experiencing weaker effects on at least 50% of Ecstasy use occasions was associated with a decrease of 0.74 days. However, the Ecstasy trajectory groups were the strongest predictors of decreased use in the unadjusted and full analyses. In the adjusted model, being in the intermediate-use trajectory was associated with a decrease of 1.07 days, while being part of the high-use trajectory was associated with a decrease of 4 days.

4. Discussion

The NHSDU prospectively examined young adults' Ecstasy use trajectories and identified relevant predictors in a population sample of recurrent users (i.e. had used Ecstasy ≥ 3 times in the year before the study). Our findings support earlier prospective research suggesting that young people's Ecstasy use is relatively transient (von Sydow et al., 2002). Further, we note the existence of dynamic trajectories involving rapid changes in levels of Ecstasy use. Our cluster analysis, based on recent Ecstasy use at four time intervals across 30 months, identified three distinct trajectories. Two trajectories were characterized by declining levels of Ecstasy use after 6 months ('intermediate' and

Table 1
Unadjusted relative risk estimates for Ecstasy use trajectories (intermediate and high use; N = 297)[a].

	N with characteristic	N without characteristic	% in each trajectory — group with characteristic[b]			% in each trajectory — group without characteristic[b]			RR — intermediate/high use[c] (95% CI)	RR — high use only[d] (95% CI)
			Low	Interm	High	Low	Interm	High		
Demography										
Sex (male)	141	156	36.2	53.9	9.9	35.3	58.3	6.4	1.06 (0.67–1.65)	1.06 (0.67–1.65)
Age (>20 years)	176	121	39.2	55.1	5.7	30.6	57.9	11.6	0.63 (0.39–1.00)	0.63 (0.39–1.00)
Married or de facto	55	242	50.9	47.3	1.8	32.2	58.3	9.5	0.43 (0.24–0.77)**	0.43 (0.24–0.77)**
Bachelor degree	33	264	33.3	54.6	12.1	36.0	56.4	7.6	1.24 (0.60–2.56)	1.24 (0.60–2.56)
Employed full-time	126	171	42.1	50.8	7.1	31.0	60.2	8.8	0.65 (0.41–1.02)	0.65 (0.41–1.02)
Studying full-time	106	191	26.4	63.2	10.4	40.8	52.4	6.8	1.84 (1.14–2.97)*	1.84 (1.14–2.97)*
Adolescent factors										
Completed secondary education[e]	210	87	31.0	60.0	9.1	47.1	47.1	5.8	1.94 (1.18–3.18)**	1.94 (1.18–3.18)**
Ever suspended from school[f]	100	197	42.0	46.0	12.0	32.5	61.4	6.1	0.66 (0.40–1.09)	2.10 (0.91–4.87) [q]
Used cannabis aged < 15 years	106	179	42.5	49.1	8.5	31.9	60.2	7.9	0.70 (0.44–1.11)	0.70 (0.44–1.11)
Psychological factors										
High psychological distress[g]	34	263	44.1	52.9	2.9	34.7	56.5	8.8	0.63 (0.32–1.25)	0.63 (0.32–1.25)
High aggression[h]	34	263	38.2	50.0	11.8	35.4	57.0	7.6	1.00 (0.49–2.05)	1.00 (0.49–2.05)
Ecstasy involvement										
High lifetime consumption[i]	140	156	25.7	62.9	11.4	44.2	50.6	5.1	2.34 (1.47–3.72)***	2.34 (1.47–3.72)***
Ecstasy use < 17 years old	46	251	37.0	56.5	6.5	35.2	56.4	8.4	0.90 (0.49–1.66)	0.90 (0.49–1.66)
Length of use: >3 years[j]	102	195	40.2	56.9	2.9	33.3	55.9	10.8	0.65 (0.41–1.04)	0.65 (0.41–1.04)
Ever sold ecstasy for profit	54	243	33.3	59.3	7.4	36.2	55.6	8.2	1.08 (0.61–1.93)	1.08 (0.61–1.93)
Ecstasy dependence (recent)[k]	17	280	11.8	70.6	17.7	37.1	55.4	7.5	3.32 (1.23–8.99)*	3.32 (1.23–8.99)*
Ecstasy dependence (lifetime)[k]	105	192	26.7	62.9	10.5	40.6	52.6	6.8	1.82 (1.13–2.93)*	1.82 (1.13–2.93)*
Other drug use										
Recent alcohol binge use[l]	171	126	29.8	62.0	8.2	43.7	48.4	7.9	1.65 (1.05–2.61)*	1.65 (1.05–2.61)*
Recent methamphetamine use[m]	39	258	15.4	71.8	12.8	38.8	53.9	7.4	2.69 (1.35–5.35)**	2.69 (1.35–5.35)**
Recent cannabis use[m]	151	146	29.8	58.9	11.3	41.8	53.4	4.8	1.85 (1.16–2.95)*	1.85 (1.16–2.95)*
Social environment										
Know > 10 Ecstasy users	270	27	53.9	57.8	8.5	33.7	42.3	3.9	2.30 (1.04–5.10)*	2.30 (1.04–5.10)*
Regular electronic/dance events[n]	143	154	21.0	67.8	11.2	49.4	45.5	5.2	3.37 (2.09–5.42)***	3.37 (2.09–5.42)***
Perceptions of Ecstasy use										
Perceive Ecstasy use as very risky	86	211	48.8	44.2	7.0	30.5	61.0	8.6	0.49 (0.30–0.81)**	0.49 (0.30–0.81)**
Strong positive effects (baseline)[o]	101	196	26.7	61.4	11.9	40.3	53.6	6.1	1.90 (1.17–3.08)*	1.90 (1.17–3.08)*
Strong positive effects (12 mths)[o]	62	235	24.2	69.4	6.5	38.7	52.8	8.5	1.58 (0.91–2.74)	1.58 (0.91–2.74)
Negative effects (baseline)[p]	35	262	40.0	51.4	8.6	35.1	56.9	8.0	0.85 (0.42–1.71)	0.85 (0.42–1.71)
Negative effects (12 mths)[p]	17	280	29.4	64.7	5.9	36.1	55.7	8.2	1.19 (0.46–3.08)	1.19 (0.46–3.08)

[a] Generalized ordered logit model using partial proportional odds. Relative risks are identical for different outcome levels except when ordinal assumptions violated.
[b] Per cent of each group (with and without characteristic) belonging to each trajectory.
[c] Relative risk obtained from contrasting low-use trajectory with higher groups (intermediate and high use).
[d] Relative risk obtained from contrasting the low-use and intermediate groups with the high use group.
[e] Received final secondary school grading.
[f] Suspended or expelled from school.
[g] Measured using Hospital Anxiety Depression Scale.
[h] Measured using aggression subscale of Young Adult Self Report.
[i] Used >70 pills ever.
[j] Reference category is 0–3 years of Ecstasy use.
[k] Ecstasy dependence assessed using WMH-CIDI (recent dependence refers to last 12 months).
[l] Refers to ≥6 standard drinks per day of use in last month.
[m] Refers to any use in the last month.
[n] Attended electronic/dance music event ≥2 times in last 12 months.
[o] Report consistent experience of high number of positive psychological effects.
[p] Report consistent experience of any negative psychological effects.
[q] Estimates differ across outcome levels.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

'high-use' groups), while the third involved stable levels of negligible use ('low-use' group). Less than one-in-ten participants belonged to the 'high-use' trajectory, which escalated during the first 6 months to using Ecstasy 1–2 days per week, but subsequently declined considerably.

4.1. Ecstasy use patterns and dependence

Membership of the intermediate and high-use trajectories (contrasted with the low-use trajectory) was reliably predicted by high lifetime quantities of Ecstasy use (at baseline) but not by Ecstasy dependence (12 month or lifetime). This suggests that young adults'

intermediate and high-use trajectories could be characteristic of intermittent binge drug use rather than dependent use. Two aspects of our DSM-IV assessment of Ecstasy dependence support this conclusion. Very few participants endorsed the 'volitional' aspect of compulsive Ecstasy use (a persistent desire or unsuccessful attempts to cut down). Secondly, only around 5% were dependent in the last 12 months. Young adults' Ecstasy use patterns could be similar to those for alcohol in the sense of binge patterns that are driven by users' expectancies (Morawska & Oei, 2005). However, while binge levels of alcohol use were common in this population, they did not serve to differentiate between Ecstasy trajectories. Our finding instead of an association between recent cannabis use and Ecstasy

Table 2
Prediction model of Ecstasy use trajectories (N = 297)[a].

	Adjusted RR — intermediate/high use[b] (95% CI)	Adjusted RR — high use[c] (95% CI)
Demography		
Sex (male)	0.73 (0.42–1.29)	0.73 (0.42–1.29)
Age (>20 years)	1.04 (0.57–1.89)	1.04 (0.57–1.89)
Married or de facto	0.64 (0.31–1.32)	0.64 (0.31–1.32)
Bachelor degree	1.97 (0.82–4.74)	1.97 (0.82–4.74)
Employed full-time	0.71 (0.39–1.31)	0.71 (0.39–1.31)
Studying full-time	1.17 (0.59–2.33)	1.17 (0.59–2.33)
Adolescent factors		
Completed secondary education[d]	1.24 (0.63–2.41)	1.24 (0.63–2.41)
Ever suspended from school[e]	0.78 (0.41–1.47)	3.01 (1.13–8.03)*,p
Used cannabis aged < 15 years	0.72 (0.39–1.33)	0.72 (0.39–1.33)
Psychological factors		
High psychological distress[f]	0.57 (0.24–1.35)	0.57 (0.24–1.35)
High aggression[g]	1.65 (0.69–3.93)	1.65 (0.69–3.93)
Ecstasy involvement		
High lifetime consumption[h]	2.73 (1.47–5.09)**	2.73 (1.47–5.09)**
Ecstasy use < 17 years old	0.92 (0.36–2.35)	0.92 (0.36–2.35)
Length of use: > 3 years[i]	0.80 (0.37–1.70)	0.15 (0.04–0.61)**,p
Ever sold ecstasy for profit	1.08 (0.52–2.25)	1.08 (0.52–2.25)
Ecstasy dependence (recent)[j]	2.24 (0.65–7.68)	2.24 (0.65–7.68)
Ecstasy dependence (lifetime)[j]	1.26 (0.68–2.33)	1.26 (0.68–2.33)
Other drug use		
Recent alcohol binge use[k]	1.40 (0.82–2.39)	1.40 (0.82–2.39)
Recent methamphetamine use[l]	1.80 (0.80–4.04)	1.80 (0.80–4.04)
Recent cannabis use[l]	2.35 (1.34–4.13)**	2.35 (1.34–4.13)**
Social environment		
Know > 10 Ecstasy users	1.60 (0.61–4.22)	1.60 (0.61–4.22)
Regular electronic/dance events[m]	2.89 (1.68–4.97)***	2.89 (1.68–4.97)***
Perceptions of Ecstasy use		
Perceive Ecstasy use as very risky	0.49 (0.27–0.88)*	0.49 (0.27–0.88)*
Strong positive effects (baseline)[n]	1.89 (1.08–3.31)*	1.89 (1.08–3.31)*
Strong positive effects (12 mths)[n]	1.11 (0.58–2.14)	1.11 (0.58–2.14)
Negative effects (baseline)[o]	0.74 (0.32–1.73)	0.74 (0.32–1.73)
Negative effects (12 mths)[o]	1.04 (0.34–3.19)	1.04 (0.34–3.19)

[a] Generalized ordered logit model using partial proportional odds, with adjustment for all variables. Relative risks are identical for different outcome levels except when ordinal assumptions violated.
[b] Relative risk obtained from contrasting low-use trajectory with higher groups (intermediate and high use).
[c] Relative risk obtained from contrasting the low-use and intermediate groups with the high use group.
[d] Received final secondary school grading.
[e] Suspended or expelled from school.
[f] Measured using Hospital Anxiety Depression Scale.
[g] Measured using aggression subscale of Young Adult Self Report.
[h] Used >70 pills ever.
[i] Reference category is 0–3 years of Ecstasy use.
[j] Ecstasy dependence assessed using WMH-CIDI (recent dependence refers to last 12 months).
[k] Refers to ≥6 standard drinks per day of use in last month.
[l] Refers to any use in the last month.
[m] Attended electronic/dance music event ≥2 times in last 12 months.
[n] Report consistent experience of high number of positive psychological effects.
[o] Report consistent experience of any negative psychological effects.
[p] Estimates differ across outcome levels.
* p < 0.05.
** p < 0.01.
*** p < 0.001.

Table 3
Prediction model of decrease in number of days of Ecstasy use, from 6 to 12 month follow-up (N = 297)[a].

	% of sample	Unadjusted coef. (95% CI)	Adjusted coef. (95% CI)
Price[b]			
20–25 dollars	42.1	−0.12 (−1.05–0.81)	0.34 (−0.56–1.23)
26–40 dollars	3.7	−0.84 (−2.48–0.79)	0.09 (−1.45–1.64)
No recent purchase	44.1	−0.46 (−1.38–0.46)	0.38 (−1.10–1.85)
Unable to obtain Ecstasy[c]			
Often	21.9	−0.11 (−0.82–0.61)	−0.39 (−1.09–0.30)
No recent use	39.7	−0.25 (−0.85–0.34)	0.25 (−1.12–1.61)
Weaker effects[d]			
On at least half the occasions	18.9	0.61 (−0.09–1.31)	0.74 (0.02–1.45)*
Haven't used last 12 mths	24.2	−0.31 (−0.94–0.32)	–[g]
'Real' Ecstasy?[e]			
Unsure/Skeptical	38.7	0.73 (0.13–1.33)*	0.41 (−0.21–1.03)
Haven't used last 12 mths	24.2	−0.10 (−0.77–0.58)	0.38 (−0.46–1.22)
Trajectories[f]			
Intermediate use	56.2	0.86 (0.32–1.39)**	1.07 (0.46–1.68)**
High use	8.1	3.67 (2.70–4.65)***	4.00 (2.93–5.06)***

[a] Linear regression model reporting coefficients with 95% confidence interval. Unit of measurement for the coefficient is the change (decrease) in last month days of use from 6 month to 12 month data collection intervals. Negative values represent an increase.
[b] Refers to purchases within the previous 6 months. Reference category is 5–19 dollars (Australian).
[c] Refers to attempts to obtain within the previous 6 months. Reference category is never/rarely unable to obtain Ecstasy.
[d] Participant asked how often (in last 12 months) the effects of Ecstasy they consumed were weaker than usual. Reference category is less than half the occasions of Ecstasy use.
[e] Participant asked how confident they were that the last Ecstasy pill they consumed contained real Ecstasy/MDMA. Reference category is very confident/confident.
[f] Reference category is the low use trajectory.
[g] Omitted due to collinearity.
* p < 0.05.
** p < 0.01.
*** p < 0.001.

4.2. Social settings and perceptions

Our findings concerning social activities suggest that young adults' Ecstasy use is largely motivated by social-recreational goals. Those who recurrently attended electronic/dance music events were almost 3 times more likely than other participants to be part of the intermediate and high-use trajectories. The self-reported 'positive' psychological effects of Ecstasy similarly predicted trajectory membership. These subjective effects are oriented toward interpersonal connectedness and physical intimacy. Consequently, young adults' Ecstasy use trajectories could represent instrumental rather than addictive behavior, especially given their limited temporal course (Hopper et al., 2006; Ramo, Grov, Delucchi, Kelly, & Parsons, 2011). It follows that the motivation to use Ecstasy may be altered as age-related social goals change. Although marriage/de facto relationships were non-significant in the adjusted analysis, this factor may be a marker for a more complex process of personal change.

Unlike the other groups, the high-use trajectory involved an initial escalation in the frequency of recent Ecstasy use in the first 6 months of the study. Drug dependence does not satisfactorily explain this increase, given the results for DSM-IV diagnostic criteria and the limited temporal nature of escalation. Other studies have also observed escalating Ecstasy use in the absence of a recognizable dependence syndrome (Degenhardt et al., 2010). One possible explanation is that rewarding aspects of Ecstasy may reinforce Ecstasy use even in the absence of other clear physiological or behavioral manifestations of dependence. Such reinforcement is not necessarily predicated on brain reward systems; certainly, animal evidence indicates that Ecstasy has a relatively weak effect on biological reward processes (Schenk, 2009). However, the

trajectories, independent of early cannabis initiation, is consistent with previous research (Degenhardt et al., 2004; Robledo, 2010). Although cannabis use generally preceded first Ecstasy use there are likely to be common pre-disposing factors underlying the concurrent use of these drugs. The association between school suspension and later high-level Ecstasy trajectories suggests that social deviance could contribute to these drug use patterns, although any such behavior does not appear to have impacted on users' social adjustment. Cannabis use may also complement the effects of Ecstasy for some users (Hunt, Evans, Moloney, & Bailey, 2009), raising the possibility that these drugs may be mutually reinforcing.

unique subjective effects of Ecstasy are closely associated with social connectedness and physical intimacy which could independently reinforce Ecstasy use. This proposition is consistent with our finding that membership of the high-use group was predicted by event attendance and the experience of strong positive subjective effects. Further, the association between the high-use trajectory and contextual factors suggests that the observed escalation is not simply attributable to random error, although this possibility cannot be completely excluded.

Changes in subjective effects reported by the high-use group could also explain the extinction of conditioned behavior. Being part of the high-use trajectory was associated with reporting strong positive subjective effects at baseline but not at the 12 month follow-up. Levels of Ecstasy use for this trajectory declined around the same time. These changes are consistent with the rapid development of chronic tolerance observed in regard to Ecstasy use (Parrott, 2005; Verheyden, Henry, & Curran, 2003). While it is possible that some users may initially compensate by increasing Ecstasy dosage, it appears that a diminution of positive effects may eventually decrease the motivation to use. Few negative effects were reported at baseline or 12 months.

Perceptions of risk were also relevant to Ecstasy trajectories. Perceiving Ecstasy use as 'very risky' significantly reduced the likelihood of being part of the intermediate and high-use trajectories. These findings suggest that credible education messages concerning the risks of Ecstasy use may limit young adults' levels of Ecstasy use over time, which is important for the reduction of Ecstasy-related harm (Baggott, 2002).

4.3. Psychological factors

This study differs from previous longitudinal research (Huizink, Ferdinand, van der Ende, & Verhulst, 2006; Lieb, Schuetz, Pfister, von Sydow, & Wittchen, 2002) in its assessment of psychological distress (i.e. symptoms of anxiety and depression) in early adulthood rather than adolescence and examination of subsequent changes in frequency of Ecstasy use. Previous studies suggest that psychological distress in adolescence may lead to later Ecstasy use, perhaps due to self-medication. However, we found no relationship between young adults' psychological distress and their Ecstasy trajectories. Our findings suggest that, if young people are using Ecstasy to self-medicate, they are doing so in adolescence, in temporal proximity to the experience of psychological distress. An alternative explanation is that distressed young adults don't use Ecstasy any more frequently than most other young adult users.

4.4. Declining Ecstasy use

We examined the association between market factors and longitudinal changes in Ecstasy use. Of all relevant factors, only perceived changes in Ecstasy quality contributed to decreases in recent Ecstasy use. This contribution was relatively small, especially with regard to the high-use trajectory. Ecstasy price and changes in availability did not appear to influence changing levels of use. This may reflect the nature of recent Ecstasy market changes in Australia, which appear to have impacted on Ecstasy quality rather than price and availability (Sindicich & Burns, 2010). Overall, market factors did not appear to greatly influence changing levels of use.

Ecstasy users' trajectories accounted for significant decreases in use, between the 6 month and 12 month follow-up, independently of Ecstasy market factors. These changes are consistent with a pattern of regression to the mean, with the greatest decrease being for the high-use trajectory, a smaller decrease for the intermediate trajectory and a relatively stable pattern for the low-use trajectory. This pattern of regression may reflect the natural history of Ecstasy use and the temporal focus of our study (Healy & Goldstein, 1978; Stout, 2008). Our prediction model of Ecstasy trajectories is suggestive of a temporal trend toward stable patterns of infrequent use in the longer-term, given that young adults who had been using for 4 years or longer were unlikely to be part of the high-use trajectory.

4.5. Strengths and limitations

This is a rare population-based prospective study of young adult Ecstasy users, recruited early in the period of their Ecstasy use, and our good participant retention after 30 months also contributes to informative mapping of trajectories. However, a number of study limitations should be noted. Firstly, although the screening response rate was reasonable compared to those routinely attained from mail-out surveys (Breen, Shakeshaft, Doran, Sanson-Fisher, & Mattick, 2010; Ryu, Couper, & Marans, 2006) bias may have resulted from non-response. Nonetheless, estimates we obtained from screening are similar to other population drug use estimates (Australian Institute of Health and Welfare, 2008) and participation rates in the NHSDU were similar for Ecstasy users and non-users. Secondly, power limitations related to sample size may limit the capacity to identify significant associations. Thirdly, the findings are period and cohort-specific and reflect the background prevalence of use. Fourthly, while the 30 month follow-up was adequate to observe major turning points in trajectories, follow-up over a longer timeframe is required to evaluate possible long-term problematic use. It is also possible that the gap between the 12 and 30 month data collection waves could have obscured interim fluctuations in levels of Ecstasy use. Additionally, we did not assess responses to drug and alcohol treatment or drug education campaigns as potential influences on decreases in Ecstasy use. In Australia there are very low rates of treatment for Ecstasy-related problems, but there has been considerable exposure to relevant campaigns. Future research should evaluate the effects of interventions on the natural history of Ecstasy use. Finally, the trajectory groups are statistically derived rather than theory-based and do not represent a formal classification.

5. Conclusions

Our prospective population-based study indicates that a majority of young adult Ecstasy users consume Ecstasy relatively infrequently and have declining levels of use before reaching their mid-twenties. Around one-in-ten have more intensive patterns of use which also decline during this period. The heavier patterns we observed appear to be characteristic of 'binge' rather than dependent patterns of drug use. Young adults' regular Ecstasy use is explicable in terms of the preponderance of positive compared to negative effects they report and also the extent of their involvement in recreational settings where Ecstasy is used. Given the transient but sometimes intensive nature of Ecstasy use, policy makers should respond to acute dangers, including toxicity due to drug interactions and engagement in risk behavior such as drug driving (Kuypers, Bosker, & Ramaekers, 2009; Mohamed, Hamida, Cassel, de Vasconcelos, & Jones, 2011). More research is required to understand the extent to which long-term neuropsychological harm results from intensive short-term Ecstasy use (Biezonski & Meyer, 2011; Green, King, Shortall, & Fone, 2012). However, the nature of Ecstasy use trajectories we observed suggests that the public health and social burden associated with Ecstasy use may be limited.

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